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CLEVELAND WATER SYSTEM[1]

By G. E. Flower[2]

LOCATION AND SOURCE OF SUPPLY

The city of Cleveland is situated on the southern coast line of Lake Erie about one-third of the way from Toledo to Buffalo. The indentation, or bay, is about 40 miles long measured from Avon Point to Fairport and about 7 miles wide. The city is located at the deepest point of the indentation. The water within the bay is nowhere deeper than 60 feet and its average depth may be taken roughly as 50 feet. The bottom is chiefly fine sand and clay, but in some places there are deposits of mud, and in a few spots the bottom is rocky. Lake Erie is the fourth in the chain of Great Lakes. At its west end it receives, through the Detroit River, the water of Lake St. Clair, Lake Huron, Lake Michigan and Lake Superior; at its easterly end the water discharges through the Niagara River and over Niagara Falls into Lake Ontario and thence into the St. Lawrence River. The lake has a length of about 250 miles, measured on a median line between the inlet and the outlet. Its greatest width is nearly 60 miles, and its average width, except at the extreme ends is about 45 miles. The surface area of Lake Erie is a little less than 10,000 square miles. The average depth is about 63 feet and its capacity is about 17,500,000 million cubic feet. The foregoing is a general description of Lake Erie, which our forefathers after much thought and consideration, decided upon as a source of supply for water.

GROWTH OF WATER WORKS

Before the water works was started and while Cleveland was just a small village, water was obtained from springs and wells. There was a good spring on the square where the old court house now stands, and also a spring of soft water on Superior Avenue near the entrance of the Old Arcade. Most of the spring water was hard and water for washing purposes was hauled up the hill from the river in barrels and wagons.

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[1] Presented at the Cleveland Convention, June 7, 1921.

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In 1854 work was started on the first pumping station. It drew its water from Lake Erie. On September 19, 1856, water was pumped into the mains, and was the cause of much jollification and celebration. The pumping equipment consisted of two Cornish beam engines and six boilers. The inlet was a pipe made of boiler plate 50 inches in diameter, extending 300 feet from shore, and 400 feet west of the western terminus of the old river bed, and into 12 feet of water. This distribution system in 1857 consisted of 13 miles of pipe mains and one reservoir of 6,000,000 gallons capacity. In 1920 the distribution system had increased to 1452 miles of pipe and four reservoirs with a combined capacity of about 157 million gallons. The average daily pumpage in 1857 was 348,700 gallons and in 1920 140,337,000 gallons.

The record shows that the number of connections with meters in 1874 was 1.28 per cent of the total number of connections. This percentage gradually increased until in 1901, it was 6.42 per cent. In 1902 the policy of metering all connections was inaugurated, so by the end of the year, 19.88 per cent of the services were metered. This policy was steadily followed until in the year 1909 practically 100 per cent of the entire supply was measured through meters.

The operation of the Cleveland water supply system may be best compared with the human body, the pumping station forming the heart of the system and the distributing pipes the veins and arteries, with the filtration plant as an added safeguard to the health of the cummunity.

Water is obtained from Lake Erie from a point some distance from the shore and is conveyed to the pumping stations by tunnels, a 9-foot tunnel to Kirtland station, located at the foot of East Forty-ninth Street and a 10-foot concrete block tunnel which divides into a 5-foot and a 7-foot tunnel, about a mile from shore, which supplies the Division pumping station located at Division Avenue and West Forty-fifth Street.

The inlets in the lake are protected by cribs, whose function is to keep out any floating logs or debris which might otherwise enter the tunnel and cause serious damage. The east side crib or intake is visible from shore, extending above the lake level, while the west side intake is submerged about 35 feet below the surface of the lake, which does away with the necessity of keeping a watchman and a light on it for protection of passing ships.

After the water reaches the shore through the tunnel it enters what is known as a screen chamber in which several screens are suspended. These screens catch all matter which passed the protection at the intake, such as sticks, leaves, fish, etc. There are two sets of screens of ½-inch mesh in the screen well, so one set may be kept in and the other removed for cleaning. From this point on, the operation of the Division and Kirtland stations is somewhat different due to the location of the filter plant at Division Avenue.

METHOD OF HANDLING THE WATER AT KIRTLAND STREET PUMPING STATION

The water after it passes the screen well flows to pump wells, one for each pump, which act as a reservoir for the pump suction. The distributing pumps, of which there are five of 130,000 million gallons a day capacity, take the water direct from those wells and pump it into the system. Steam for running the pumps is generated by eight boilers. The coal is delivered to the station on an overhead track and dumped directly into the storage bins. Up to September 11, 1911, the water was pumped into the mains without any treatment, but on that date an apparatus was installed for the application of calcium hypochlorite. This method of treatment was used, except for a short period in 1916, when an electrolyzed salt solution was applied in place of the bleaching powder, until the installtion of Wallace and Tiernan liquid chlorine machines, on July 16, 1917. These are still in operation at the pumping station. The chlorine is not "shoveled into the water" as some people imagine, but is accurately and closely controlled by sensitive valves and scales.

FILTRATION PLANT AT DIVISION AVENUE

The water is drawn from the tunnel through the screens located in the screen well and is forced by turbine driven centrifugal pumps to the filter plant. There are three low lift filter plant supply pumps, two capable of pumping 100,000,000 apiece and one capable of pumping 60,000,000 gallons of water a day. The water is forced by these pumps through a 72-inch riveted steel pipe to the mixing chambers from where it flows by gravity. As the water passes through the chemical house on its way to the mixing chambers it is measured by a large 72 by 42 inches Venturi meter. This affords the men in charge an opportunity of regulating the amounts of chemicals to be added to the water.

Chemical House. The chemicals are shipped in box cars onto a railroad track alongside of the chemical house where they are unloaded by scoop-shovels into a chute through a crusher, of the flail type, to a bucket elevator. The latter elevates the chemical to the top floor of the chemical house into a worm conveyor, which conveys it to separate storage bins. The are eight lime or aluminum sulphate storage bins of 1500 tons total capacity, and two iron sulphate storage bins of 400 tons total capacity.

The chemicals are taken from the bins through the chutes to the different scales. After leaving the scales, the chemicals drop into the slaking tanks and solution tanks where they are put into solution. The solution is forced into the water by six Penberthy water injectors.

Mixing chambers. The water passes from the chemical house into four mixing chambers where the water is agitated, causing the water and the chemicals to become thoroughly mixed. This mixing is done by forcing the water over and under wooden baffles, and also back and forth through narrow channels. The agitation period in the mixing chambers varies from ½ to 1 hour. The water then flows into the settling basins.

Settling or coagulation basins. There are six basins, each holding about 3,500,000 gallons. Each basin is divided into three compartments. The water flows down one compartment and around the end of a baffle back through the middle compartment around the end of a second baffle and then through the third compartment over a skimming weir into a long gallery. The water flows from here through four 48-inch cast iron pipes to the filters.

During the period of three and one-half to four and one-half hours in the settling basins about 75 per cent of the suspended matter and a certain proportion of the bacteria are precipitated. Each settling basin and mixing chamber is independent of the other and may be shut off, drained and cleaned by flushing. Cleaning is done about once a year.

Filters. The water flows from the settling basins to the filters and then to the clear water basin.

There are 36 filter units equipped with the usual recording and regulating devices. Each filter has an operating table, which is used in operating the five hydraulic valves connected to the filter. Each filter has 27 inches of quartz sand of 0.45 mm., effective size and 22 inches of graded gravel, the latter ranging in size from one and one-half inches to the coarse sand at the bottom of the sand layer. The average period of service for each filter is about thirty hours. The actual time of washing is about three minutes. The filtered water leaves the filter through a concrete twin conduit leading to the filtered water reservoir, where there is applied one pound of liquid chlorine per million gallons of water, for disinfection purposes.

Laboratory. At the Division Avenue filtration plant, samples are taken three times daily of the raw, settled, filtered and disinfected water and once a day at the Kirtland Street pumping station of the raw and disinfected water. From these samples, bacteria and chemical tests are made which enable the operator to have scientific control of the operation. The Division of Water has one of the best equipped laboratories in the country for water, oil, coal and cement testing.

GENERAL FILTER PLANT DATA

Capacity 150,000,000 gallons per twenty-four hours.

Coagulants used: Lime (CaO)—0.6 grain per gallon; sulphate of iron ($FeSO_4 \cdot 7H_2O$)—0.8 grain per gallon; sulphate of alumina $Al_2(SO_4)_3 \cdot 18\,H_2O$,—0.8 grain per gallon.

Mixing period—forty-five minutes.

Settling period—four hours.

Number of filters—36.

Capacity of each filter—$4\frac{1}{6}$ million gallons per twenty-four hours.

Rate of filtration 125,000,000 gallons per acre per day.

Rate of wash, 20 gallons per square foot per minute.

Area of each filter, 1454 square feet.

Filtered water reservoir, 20,000,000 gallons capacity.

Area occupied—20 acres.

Total excavation—640,000 cubic yards.

Total concrete placed—125,000 cubic yards.

Original cost (exclusive of land): Filtration plant, \$2,225,000; pumping station, \$1,220,000; crib and tunnel, extension, \$1,200,000; total, \$4,645,000.

Cost of filtration per million gallons of water for 1920: Operation, supervision, labor and supplies, \$2.22; chemicals \$1.45; labor and material for maintenance, \$0.80; total \$4.47.

The large triple expansion pumps which pump the water to the distributing system about the city are located at the pumping station.

They draw the water from the filtered water reservoir and pump it under pressure into the mains and reservoirs located in other parts of the city. There are six pumps at Division pumping station, two, having a combined capacity of 30,000,000 gallons daily, pump into the first high service territory and four, having a combined capacity of 90,000,000 gallons a day, pump into the low service territory. There is now in course of construction one 20,000,000 turbine driven centrifugal to be used for the first high service territory. Steam for operating these pumps and the low lift pumps is generated in six 500-h.p. boilers. Coal is handled by conveyors and elevators and stored into bins. All the water used in boilers is metered and the coal is weighed at each boiler by automatic scales.

RESERVOIRS

There are five storage, or equalizing reservoirs, that equalize the pressures in the separate districts and also serve as sources of supply for other services.

Fairmount reservoir, with a capacity of 80,448,400 gallons, consists of two basins and is used for supplying the low service districts and also used as a source of supply for the pumps at Fairmount pumping station, to pump the water into first and second high service.

Kinsman reservoir, with a capacity of 35,219,700 gallons, is the supply for the first high service district.

Warrensville reservoir, with a capacity of 22,250,000 gallons, is the supply for the second high service district, and is used as a source of supply for the pumps at Warrensville pumping station for the third high service district.

The steel tower holding 200,000 gallons is used for the third high service district.

The clear water reservoir is the suction well for the vertical, triple expansion pumps located at Division Avenue pumping station, which pumps the filtered water into the service.

DISTRIBUTION SERVICE

Due to the natural topography of the city of Cleveland and adjacent towns which it supplies with water, the distributing system is divided into four different territories known as low, first high, second high and third high services. The low service district, the largest, takes in all teritory that lies between city datum and 120 feet above it. City datum is 2.34 feet above average lake level. First high service district embraces the territory between 120 and 250 feet above city datum, second high service between 250 and 500 feet above city datum and third high service over 500 feet above city datum.

River tunnels. In order to facilitate easy accessibility in case of leaks in the water mains that carry the water from one side of the Cuyahoga River to the other, five tunnels were driven under the river. They were placed at sufficient depth below the bottom of the river so that there is no danger of breakage. The five river tunnels are located as follows:

St. Clair Avenue tunnel, 7½ feet in diameter, completed in May, 1891.

Clark Avenue tunnel, 8 feet in diameter, completed in July, 1895.

Main Street tunnel, 8 feet in diameter, completed March, 1897.

Superior Avenue tunnel, 8 feet in diameter, completed in December, 1897.

Central Avenue tunnel, 10 feet in diameter, completed in July, 1916.

Pipe distribution system. The sizes of water mains range from 3 inches to 48 inches in diameter. Fire hydrants are placed at intervals of about 300 feet. The general rule is to lay the pipes at least 6 feet deep, but this cannot always be followed. The service connections are lead pipe up to 1 inch size, wrought iron pipe from 1 inch to 3 inch size and above 3 inch size cast iron pipe. Stop cocks enclosed in a cast iron box are placed 1 foot inside the curb on all service connections up to 3 inch size, and from 3 inch up to 6 inch size, are usually placed about two feet from the main. Gate valves are so placed that if there is a break in the main, the break can be isosolated by closing a few valves. During the repair work the water is diverted so that as small as number as possible of services is deprived of its use.

Cleveland is the only city with a population over 100,000 that is 100 per cent metered. The meter in general use is of the small disc type, but the velocity type is also used in certain places. A repair department maintained by the Division of Water is located at Woodland Yard, where all meters are repaired and tested. A day and night service is maintained by the Department in case of breaks or for any emergency.

The Water Department sets the hydrants for fire protection all over the city without any additional charge, and also provides the meters and sets same without any charge. It is the only city of any size in the United States that is doing this without charging extra for the service.

It is found in comparing Cleveland's water rates with the ten largest cities in the United States, that Cleveland's rates are among the lowest.

	PER 1000 CUBIC FEET	MAXIMUM OR MINIMUM
New York	$1.00	With no minimum
Chicago	$0.62½	With no minimum
Philadelphia	$1.00	Maximum, $0.40 minimum
Detroit	$1.00	Maximum, $0.35 minimum
Cleveland	$0.60	Maximum, $6.00 per year minimum
St. Louis	$1.50	Maximum, $0.50 minimum
Boston	$1.54	Maximum, $0.88 minimum
Baltimore	$0.65	Maximum,
Pittsburgh	$1.35	Maximum, $0.90 minimum
Los Angles	$1.00	Maximum, $6.00 per year minimum

DIVISION OF WATER PROVIDES SUPPLY FOR METROPOLITAN SYSTEM

The city supplies all of the suburbs with water. In connection with this, the Division of Water bears the cost of inspection at the foundries of all pipe, special castings, valves and hydrants that are used in the construction of the system and also the cost of inspection during installation. In many of the suburbs the city collects from the consumers directly, besides rendering them the service mentioned above.

All plans for installation of water pipe must be first approved by the Division of Water. Lot owners and people who are contemplating allotting their property, apply to the Division of Water for information regarding the Department's ability to furnish them water. In many instances this is done before it is taken up with the suburbs affected. In other words, the Division of Water stands the burden of the cost of investigation of the possibilities of supply to care for future growth. In many of the suburbs the city installs the service connections, meters and meter vaults, but at the cost of the consumer.

The Division of Water from its inception has endeavored to meet the demands for water of a growing city, and is still making an earnest effort to forecast the future needs of a metropolitan center, both as to quantity and quality of its water supply.